



US009410261B2

(12) **United States Patent**
Hougham et al.

(10) **Patent No.:** **US 9,410,261 B2**
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **TWO MASK PROCESS FOR
ELECTROPLATING METAL EMPLOYING A
NEGATIVE ELECTROPHORETIC
PHOTORESIST**

(71) Applicant: **GLOBALFOUNDRIES INC.**, Grand
Cayman (KY)

(72) Inventors: **Gareth G. Hougham**, Ossining, NY
(US); **Gerard McVicker**, Stormville,
NY (US); **Anna Pratt**, Wallkill, NY
(US)

(73) Assignee: **GLOBALFOUNDRIES INC.**, Grand
Cayman (KY)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/528,028**

(22) Filed: **Oct. 30, 2014**

(65) **Prior Publication Data**

US 2015/0060266 A1 Mar. 5, 2015

Related U.S. Application Data

(62) Division of application No. 13/584,326, filed on Aug.
13, 2012.

(51) **Int. Cl.**
C25D 17/12 (2006.01)
G03F 7/20 (2006.01)
G03F 7/00 (2006.01)
C25D 1/00 (2006.01)
C25D 5/02 (2006.01)
C25D 13/00 (2006.01)

(52) **U.S. Cl.**
CPC **C25D 17/12** (2013.01); **C25D 1/003**
(2013.01); **C25D 5/022** (2013.01); **G03F**
7/0037 (2013.01); **G03F 7/203** (2013.01);
G03F 7/2022 (2013.01); **C25D 13/00**
(2013.01); **Y10T 428/24562** (2015.01)

(58) **Field of Classification Search**
CPC H01L 21/32
USPC 204/290.01; 430/324
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,861,327 A	1/1999	Maeng et al.
5,928,815 A	7/1999	Martin
6,391,773 B2	5/2002	Andricacos et al.
2011/0108316 A1	5/2011	Hougham et al.
2011/0111647 A1*	5/2011	Hougham H01L 21/486 439/884
2011/0236833 A1	9/2011	Chan

OTHER PUBLICATIONS

Jeon, S. et al., "Fabricating Complex Three-Dimensional Nanostructures with High-Resolution Conformable Phase Masks" PNAS (Aug. 24, 2004) pp. 12428-12433, vol. 101, No. 34.
Beuret, C. et al., "Microfabrication of 3D Multidirectional Inclined Structures by UV Lithography and Electroplating" IEEE Workshop on Micro Electro Mechanical Systems (Jan. 25-28, 1994) pp. 81-85.
Notice of Allowance issued on Jan. 15, 2016 in U.S. Appl. No. 13/584,326.

* cited by examiner

Primary Examiner — Daborah Chacko Davis

(74) *Attorney, Agent, or Firm* — Scully Scott Murphy and Presser

(57) **ABSTRACT**

A negative electrophoretic photoresist is applied over a plurality of protruding disposable template portions on a substrate. A silo structure is placed on planar portions of the negative electrophoretic photoresist that laterally surround the plurality of protruding disposable template portions. The negative electrophoretic photoresist is lithographically exposed employing the silo structure and a first lithographic mask, which includes a transparent substrate with isolated opaque patterns thereupon. After removal of the silo structure, the negative electrophoretic photoresist is lithographically exposed employing a second lithographic mask, which includes a pattern of transparent areas overlying the planar portions of the negative electrophoretic photoresist less the areas for bases of metal structure to be subsequently formed by electroplating. The negative electrophoretic photoresist is developed to form cavities therein, and metal structures are formed by electroplating within the cavities. The negative electrophoretic photoresist and the plurality of protruding disposable template portions can be subsequently removed.

15 Claims, 22 Drawing Sheets